JOHN SPELLMAN
Governor

Publication No. 82-e27

WA-39-1034

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
7272 Cleanwater Lane, LU 11 • Olympia, Washington 98504 • (206) 753-2353

MEMORANDUM
October 25, 1982

To: Files

From: Bill Yake BY

Subject: Renton Treatment Plant, Water Quality Issues: Response to PSCOG Working Paper

This memorandum provides an overview of water quality issues related to the Renton STP discharge based on a review of current WDOE monitoring data, the Puget Sound Council of Government's Working Paper (PSCOG, 1982), telephone discussions with Pete Beaulieu, and earlier WDOE study reports (Bernhardt, 1981; Yake, 1981). Figure 1 shows the lower Green/Duwamish system and pertinent WDOE routine monitoring stations.

Issues discussed are primarily limited to dissolved oxygen (D.O.), un-ionized ammonia (NH_3^0-N), and total residual chlorine (TRC). Other constituents addressed in the "Working Paper" include temperature and fecal coliform, as well as metals and other toxics. It appears to be generally accepted that, although it would be costly; D.O., NH_3^0-N, and TRC receiving water problems associated with the Renton discharge could be solved without removing the effluent from the river. Metals and temperature problems do not appear amenable to any solution other than removing the discharge. There is little information available to suggest that the Renton discharge is a significant cause of fecal coliform problems in the river.

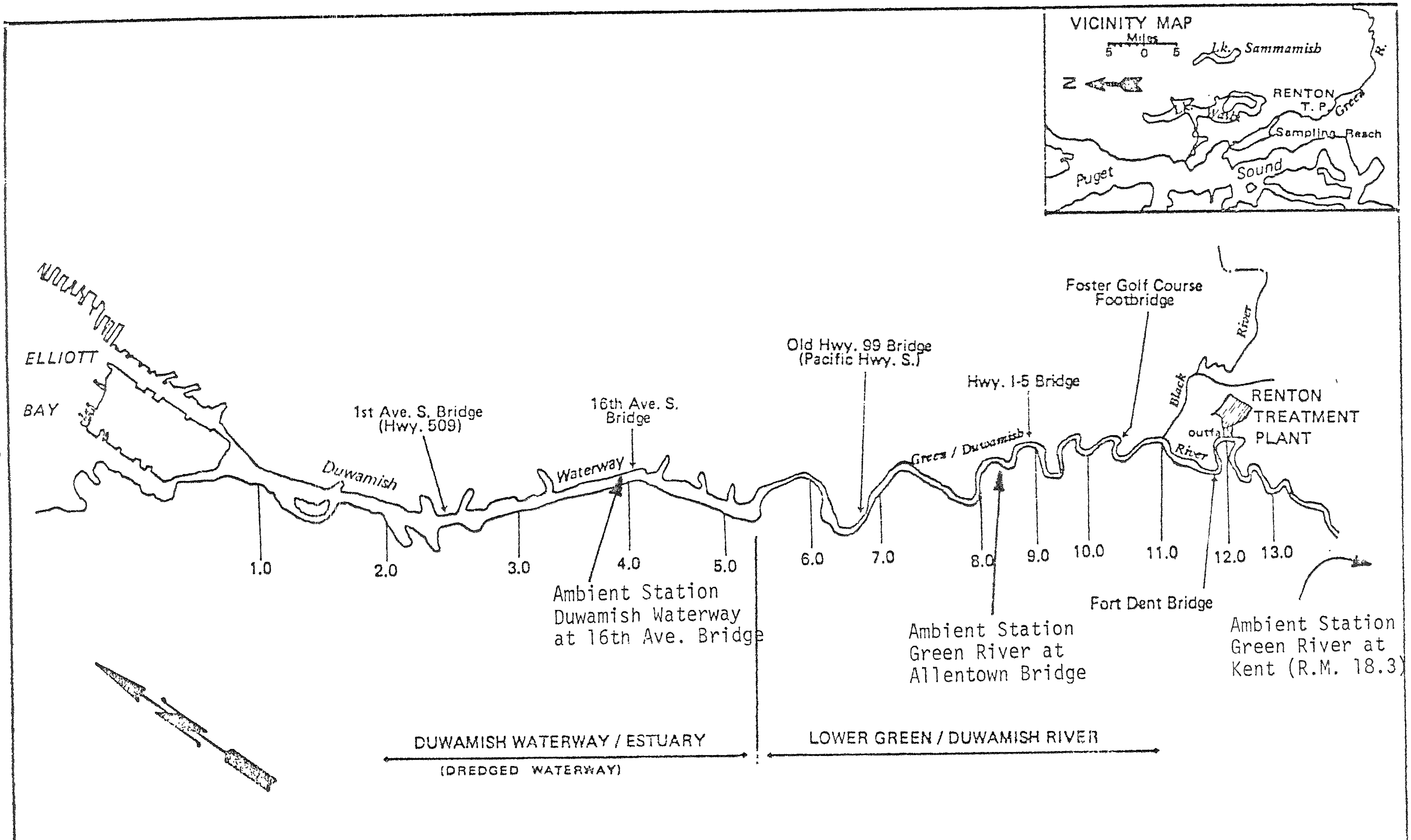

Figure 1. DUWAMISH RIVER INTENSIVE STUDY AREA WITH RIVER MILE INDEX

Original:
Duwamish River Intensive
Survey Memorandum
by John Bernhardt
Dec. 19, 1979

Each issue will be discussed separately. Discharge limits for effluent constituents implicated in each receiving water quality problem will be suggested based on presently available information. These limits are those considered adequate to prevent violations of state water quality standards and/or EPA water quality criteria.

Dissolved Oxygen: Renton effluent depresses dissolved oxygen concentrations in surface water segments with three state D.O. standards. The reach upstream of the Black River (River Mile [R.M.] 11) has a Class A standard of $\geq$ 8.0 mg/L; the reach from R.M. 11 to salt water (R.M. 5 to 8 depending on tide stage) has a Class B (freshwater) standard of $\geq$ 6.5 mg/L; and the final reach (to R.M. 0) has a Class B (marine) standard of $\geq$ 5.0 mg/L. The primary cause of depressed D.O. concentrations in the lower Green River is in-stream nitrification of ammonia discharged by the Renton Plant (Yake, 1981). Figure 2 shows the results of a model developed to predict in-stream D.O. concentrations in the river under a range of Renton effluent loadings.

Current Status:

- D.O. concentrations of as low as 8.2 mg/L have been recorded upstream of the Renton discharge, R.M. 18.3 (WDOE ambient data, Green River at Kent, July 1980 to present).

- Violations of the D.O. standard have been recorded below the plant. Values of 7.4 to 7.9 mg/L have been reported near the discharge under "triple-dose" concentrations, R.M. 11-12 (Bernhardt, 1981; Yake, 1980). Concentrations of 6.2 and 6.3 mg/L were recorded in July and August of 1980 at R.M. 8.3 (WDOE ambient data, Green River at Allentown Bridge).

- Concentrations as low as 4.9 to 5.3 mg/L have been recorded in surface waters of the Duwamish Waterway at the 16th Avenue Bridge, R.M. 3.9 (WDOE ambient data; Bernhardt, 1981).

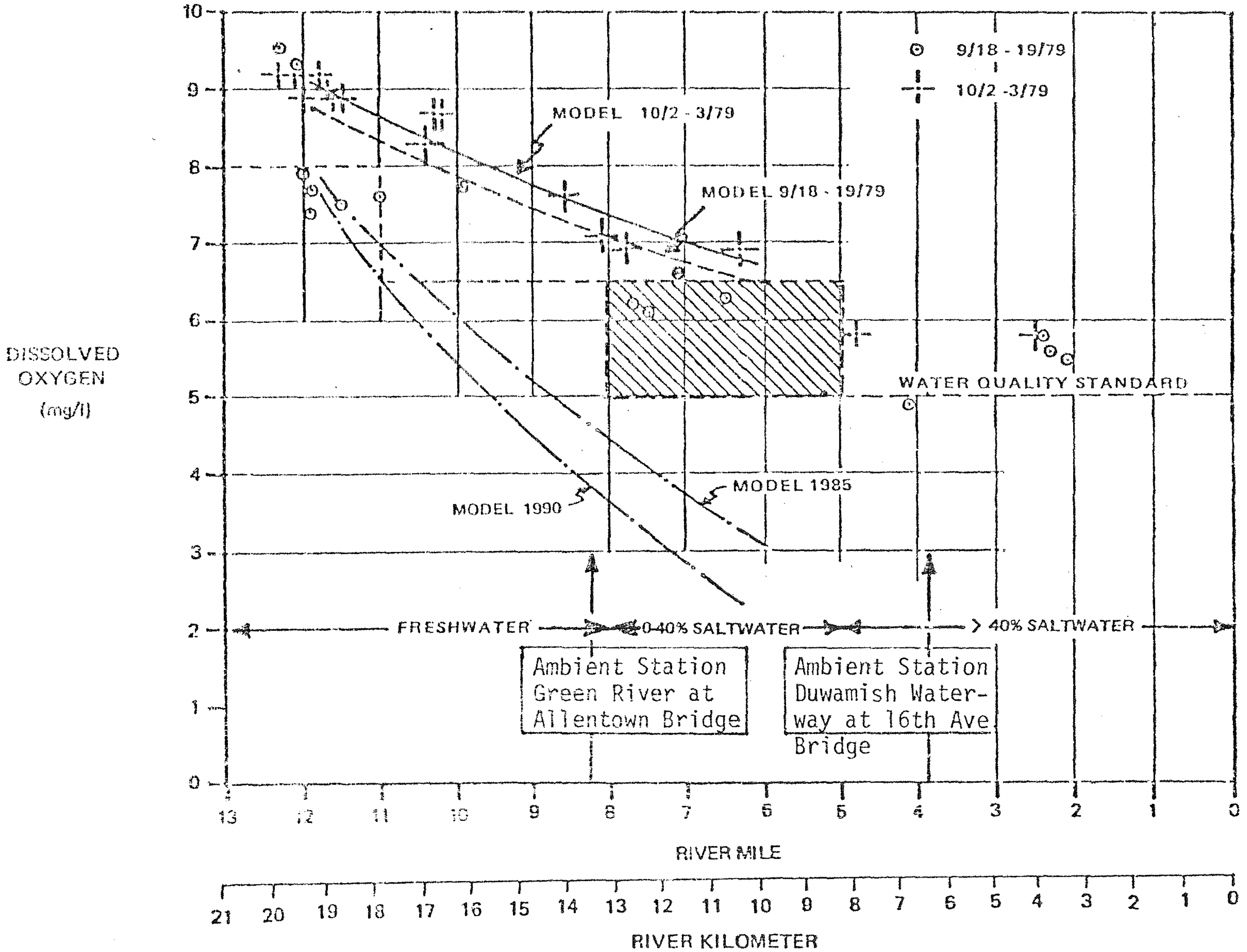

Figure 2. Dissolved oxygen profile, Green/Duwamish River.

The primary cause of D.O. depletion in the lower Green/Duwamish River and in <u>surface</u> waters of the dredged waterway is ammonia discharged from the Renton plant. Low D.O. concentrations in the Renton effluent contribute to D.O. standards violations near the discharge. All available information suggests that as ammonia loads from the plant increase, downstream and waterway surface D.O.s will be further depressed.

PSCOG Working Paper:

- Appears to question "reasonableness" of WDOE water quality standards.

    Response: Not negotiable

- Considers impacts on beneficial uses "minimal".

    Response:

    - Water quality standards are being violated.

    - D.O. concentrations at the Allentown Bridge site are generally the lowest measured at any fresh-water station in WDOE's ambient network (65 state-wide stations).

    - Modeling suggests that all dissolved oxygen in the river will be depleted when peak daily ammonia loads (12 noon to midnight) are approximately double the current effluent loads. This assumes "moderate worst cases" (low flow) conditions.

- Suggests Renton plant is responsible for only about 25% of the current D.O. depletion observed (PSCOG, 1982; Tables 2 and 3).

    Response: Misleading analysis. The winter-to-summer decrease of "13 mg/L to 6.5 mg/L" is largely a natural, physical phenomenon related to water's ability to hold dissolved oxygen at various temperatures. A preferable analysis would look at percent saturation values upstream and downstream of the plant. Table I does this. Based on Table I, Renton is responsible for about 64% of the observed depletion on an annual basis, and about 74% of the depletion observed in the July-to-October period.

Table I. Percent oxygen saturation - Green River (from WDOE Ambient Data; July, 1980, to present).

Station	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Green River, 212th St., Kent (mean monthly % saturation)	93.2	96.3	94.8	97.8	97.6	94.3	90.7	98.1	94.7	91.9	92.7	99.4
Green River, Allentown Bridge (mean monthly % saturation)	89.1	93.9	89.4	91.9	92.1	86.8	72.8	81.5	76.2	78.2	84.9	93.0
Percentage of Total Depletion attributable to Renton discharge	39	39	51	73	70	57	66	90	76	63	52	91

It should be noted that the Allentown Bridge is not at the lowest point in the D.O. sag. Downstream D.O. concentrations and percent saturation levels would be even lower.

- Notes an effluent standard of 8.0 mg/L (Table III).

  Response: There is no current effluent D.O. standard. However, it an excellent idea and is proposed further along in this section.

- Makes several statements about future additional depletions due to increasing flows at the Renton plant.

  Response: These statements are generally suspect. Tables II A and B give predicted D.O. concentrations at R.M. 6 for a range of treatment plant flows. Daily average flows of 36, 72, and 144 MGD were modeled along with three respective "peak" flows. "Peak" flows are flows observed at the plant from 12 noon to midnight and average 150% daily average flows. Table II A assumes an effluent ammonia (NH_3-N) concentration of 15 mg/L; Table II B assumes a fully nitrified effluent of 1 mg NH_3-N/L. Other model inputs assume moderate worst-case (summer low flow) conditions.

Table II A. Modeled dissolved oxygen concentrations at R.M. 6 (effluent ammonia concentration: 15 mg NH_3-N/L).

Average Daily Flow (MGD)	36		72		144	
Modeled Flow (MGD)	36	54	72	108	144	216
Dissolved Oxygen Concentration (mg/L)	5.13	3.90	2.87	1.24	0.01	0.00

Table II B. Modeled dissolved oxygen concentrations at R.M. 6 (effluent ammonia concentration: 1.0 mg NH_3-N/L).

Average Daily Flow (MGD)	36		72		144	
Modeled Flow (MGD)	36	54	72	108	144	216
Dissolved Oxygen Concentration (mg/L)	8.07	7.95	7.85	7.68	7.56	7.39

Suggested Effluent Limits:

1. Effluent dissolved oxygen concentrations should be $\geq$ 8.0 mg/L. This might be relaxed on a seasonal basis.

   Rationale:

   Background (upstream) concentrations down to 8.2 mg/L have been recorded (see earlier discussion). The receiving water quality standard at the discharge is 8.0 mg/L. Due to the "triple-dose" effect, over 50% of the river water at the discharge may be effluent. The only way to assure maintenance of the standard is to require at least 8.0 mg D.O./L in the effluent.

2. Daily average effluent loads of ammonia-nitrogen should not exceed 1,000 to 2,500 lbs/day. Again, this would apply primarily during the summer-fall period. This range of limits is based on model output. A range is given because the limit varies with the assumptions fed to the model. A limit of 1,000 lbs/day prevents all but marginal violations in the Class A segment when a peak (noon to midnight) load of 1,500 lbs/day is discharged under moderate worst-case conditions. Higher limits are obtained when peaking is not considered and less restrictive worst-case conditions are applied. Table III translates loads into effluent concentrations at various flows.

Table III. Effluent ammonia-nitrogen concentrations (mg NH_3-N/L) equivalent to various effluent ammonia loads (lbs NH_3-N/day).

Effluent Loads (lbs NH_3-N/day)	1,000	1,500	2,000	2,500
Flow (MGD)				
36	3.33	5.00	6.66	8.33
40	3.00	4.50	6.00	7.49
50	2.40	3.60	4.80	6.00
60	2.00	3.00	4.00	5.00
72	1.67	2.50	3.33	4.16
100	1.20	1.80	2.40	3.00
144	0.83	1.25	1.67	2.08

3. Carbonaceous BOD_5 concentrations should not exceed 10 mg/L. This is included because it is the value entered into the model. It could be increased, but this would result in an equivalent decrease in the allowable effluent ammonia load.

Un-ionized Ammonia (NH_3^O-N): The Renton treatment plant is responsible for approximately 80 to 95% of the total ammonia in the lower Green River and surface waters of the Duwamish Estuary. The EPA criterion for un-ionized ammonia is 0.02 mg NH_3^O/L; or, on a nitrogen basis, 0.017 mg NH_3^O-N/L. This criterion is designed to protect against in-stream toxicity to fish. The fraction of total ammonia (NH_3^T-N) present as un-ionized ammonia (NH_3^O-N) is a function of temperature and pH. A larger fraction is present in the un-ionized form as temperatures and pH increase.

Current Status:

- NH_3^O-N concentrations above the EPA criterion have been noted during recent years at two locations:

    1. Near the Renton discharge. Concentrations of NH_3^O-N from 0.020 to 0.076 mg/L were noted from R.M. 10 to 12 during a period of low river flow and tide reversal (Bernhardt, 1981).

    2. In surface waters of the Duwamish Waterway. On four occasions over the past two years, NH_3^O-N concentrations ranging from .017 to .026 mg/L have been recorded in surface waters near the 16th Street Bridge (WDOE ambient monitoring data, Duwmaish Waterway at 16th Street Bridge, July, 1980, to present.)

- NH_3^O-N concentrations at the Allentown Bridge station are generally below the criterion. A maximum value of .012 mg NH_3^O-N/L has been recorded at the Allentown Bridge station. Values are lower here because total NH_3^T-N concentrations are not as high as at the discharge under "triple-dose" conditions, and pH in the river is generally lower than in the waterway/estuary.

The Renton plant is responsible for 80 to 90% of all ammonia in the lower river/estuary. Un-ionized ammonia concentrations at the 16th

Street station are higher than values at any other WDOE station in WDOE's network (130 statewide stations).

PSCOG Working Paper:

- Accepts that Renton is essentially the sole source of ammonia to the river.

- Does not recognize current violations of criteria in the waterway/estuary.

  Comment: Pete Beaulieu was not aware our data showed recent values above EPA criteria in the Waterway.

- Suggests that "restoration of ample aeration capacity at the plant could dramatically reduce ammonia discharge".

  Response: This is an over-simplification. Achieving reliable in-plant nitrification would require special design of aeration basins, aerators and secondary clarifiers; size and detention times would have to be increased. Power costs would increase. Increased detention times would probably increase summer discharge temperatures thus aggravating the in-stream temperature problems.

Suggested Effluent Limits:

Developing an appropriate limit for effluent ammonia to prevent in-stream un-ionized ammonia toxicity is difficult as it depends on what assumptions are made about receiving water temperatures and pH. Summer pH values in the waterway have fallen from about 9.0 to 8.0 over the past 10 years due to the decline of algae blooms in recent years. If one uses recent history as a basis, a decrease of approximately 50% in current effluent concentrations and loads would probably eliminate most receiving water violations. This would result in limits roughly equivalent to those listed for NH_3-N in the section on D.O. (i.e., concentrations of up to 7 mg NH_3-N/L and loads of 1,500 to 2,000 lbs NH_3-N/day).

If high pH values (approximately 9.0) in the estuary were to recur, effluent limitations would have to be much more severe (less than 1 mg NH_3-N/L, less than 200 lbs/day).

Total Residual Chlorine (TRC):

The Renton plant is the sole known source of residual chlorine in the Green/Duwamish system. Effluent concentrations are generally 0.20 to 0.25 mg/L although values of at least 0.32 mg/L (Yake, 1980) have been reported. The EPA receiving water criterion is 0.002 mg/L and the current effluent permit limit is .008 mg/L.

Current Status:

- The only reported measurements of TRC in the Green/Duwamish are those made by Bernhardt (1981). He found concentrations (.01 to .20 mg/L) 5 to 100 times the criterion from the discharge point at least 3.2 miles downstream.

PSCOG Working Paper:

- Appears to accept necessity of eliminating TRC discharges.

- Suggests dechlorination is "somewhat less reliable" than removing effluent from the river.

- Suggests decreasing effluent ammonia could result in lower TRC discharges.

  Response: This assertion is incorrect.

Other Comments:

- If dechlorination were not followed by reaeration, excess SO_2 addition could result in immediate oxygen demand and in-stream D.O. problems. Requiring effluent reaeration to 8.0 mg/L would eliminate this problem.

- Other means of disinfection (IR, ozone) could also be used to solve the TRC problem.

Suggested Limit:

Rationale is available for lowering the current effluent limit of .008 mg/L. Under "triple-dose" conditions, greater than 50% of the river water near the discharge can be effluent. Because the dilution ratio under these conditions drops below 1:1, an effluent limit of .004 could be justified. As plant flows increase, this limit would have to approach the receiving water criterion of .002 mg/L.

Metals: EPA receiving water criteria for metals are given in two forms. The first is a "chronic" or 24-hour criteria which should not be exceeded on a long-term (24 hours or greater) basis. The second is an "acute" or instantaneous criteria which should not be exceeded at any time. Many of EPA's metals criteria are determined as a function of water hardness (the harder the water, the less restrictive the criteria). Measurements of Green River water hardness at the Allentown Bridge station range from 20 to 48 mg/L as calcium carbonate. This indicates a very soft water, thus metals criteria are quite restrictive. Table IV A gives applicable criteria over this hardness range, total recoverable metals concentration ranges at Allentown station since November, 1981, and effluent concentrations reported in a WDOE effluent monitoring report (Yake, 1980) and the Working Paper (PSCOG, 1982).

Table IV A. Total recoverable metals: Renton STP, Green River and criteria (all units µg/L).

Metal	EPA Criteria: 24-hr., chronic	EPA Criteria: Acute	Range of Receiving Water Concentrations Green River/Allentown	Renton STP Effluent Concentration: WDOE Survey	Renton STP Effluent Concentration: PSCOG Working Paper	Comments - Comparing Criteria to Receiving Water Data
Cadmium	.005 - .012	0.05 - 1.4	<0.1 - 0.50	6	4	Chronic criteria generally exceeded.
Chromium	44	825 - 3600	<0.8 - 8	<10		No problem.
Copper	5.6	4.9 - 11	1.4 - 7.5	30	40	Chronic, acute criteria occasionally exceeded.
Mercury	0.2	4.1	<.05 - 0.15	0.31	1.5	Chronic criterion being approached.
Lead	.087 - 0.68	24 - 70	1.2 - 31	<50	50	Chronic exceeded, acute occasionally exceeded.
Zinc	47	84 - 174	<5 - 70	60	90	Chronic occasionally exceeded.

Table IV B. Average percent increase in total recoverable metals (11/81 - present); Green River (Kent to Allentown).

Metal	Average Percent Increase
Cd	+25%
Cr	+33%
Cu	+88%
Hg	-6%
Pb	+38%
Zn	>+35%

In comparing receiving water concentrations, EPA criteria, and effluent concentrations, it appears that Renton effluent now contributes to excursions above the chronic and/or acute criteria for cadmium, copper, zinc, and very possibly lead.

Table IV B gives the average percent increase for each metal between the upstream (Kent) and downstream (Allentown) stations.

Summary of Suggested Effluent Limits:

The following effluent limits are suggested, if the plant discharge were to remain in the river. These limits should be adequate to prevent in-stream concentrations from exceeding standards and criteria for D.O., ammonia toxicity, and TRC. Metals and temperature limits are not addressed here.

Table V. Suggested Permit Limits

Dissolved oxygen:	$\geq$ 8.0 mg/L
Total Ammonia-N:	$\leq$ 6 to 7 mg/l; and $\leq$ 1000 to 2500 lbs/day
Total Residual Chlorine:	$\leq$ .002 to .008 mg/L
Carbonaceous BOD_5:	$\leq$ 10 mg/L

Other Comments:

Temperature:

- Increasing the wastewater detention time to permit nitrification would result in higher summertime effluent temperatures. This could aggravate the in-stream temperature problem.

Plant Upset or Malfunction:

- Probably one of the most important issues with respect to protecting in-stream fisheries resources is the potential for a major fishkill in the case of plant upset or malfunction. The very low current dilution ratio (now down to 4:1) leaves virtually no buffer. Spills to the plant, sludge bulking problems, or equipment malfunction could lead to a major degradation in effluent quality and subsequent fishkills. Systems capable of detecting effluent degradation and providing adequate holding capacity at the plant would be impractical and very expensive.

Fish Avoidance:

- The concept that fish will avoid water quality problems and thus limit the potential for major kills has been raised. For instance, the Working Paper states, "migrating fish apparently avoid blocks of highly chlorinated water." Generally, fish response to pollutants is not well understood. It is dependent on the type of pollutant and hydraulogy, as well as species, life cycle stage, and condition of the fish. The ability of fish to avoid toxic conditions is often overestimated.

BY:cp

CITATIONS

Bernhardt, J.C., 1981. *Effects of Renton Wastewater Treatment Plant Effluent on Water Quality of the Lower Green/Duwamish River.* DOE Report No. 81-2. 35 pp.

PSCOG, 1982. *A Working Paper and Data Worksheet on Duwamish Estuary Water Quality Issues.* 15 pp.

Yake, W.E., 1981. *The Impact of Effluent from the Renton Wastewater Treatment Plant on the Dissolved Oxygen Regimen of the Lower Green/Duwamish River.* DOE Report No. 81-2. 19 pp.

Yake, B., 1980. *Renton STP Class II Inspection.* Memorandum to David Wright, January 4, 1980. 23 pp.